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OFFICE AUTOMATION AND PRODUCTIVITY:

STATUS REPORT

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This report, is one of a series of research papers that are result of work done by or for the Organizational Research Directorate, Canadian Workplace Automation Research Centre, Communications Canada. This views expressed in this report are those of the authors.

* La version française du rapport est aussi disponible.

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FOREWORD

This report presents the findings of a research project on the methods, models, schools of thought and approaches to measurement of productivity in an office automation environment.

It has been prepared by a team from the Organizational Research Directorate of the Canadian Workplace Automation Research Centre (CWARC).

This document is part of a series of publications on productivity and office automation. This series includes a bibliography, an annotated bibliography, texts of papers given at conferences of various learned societies and a document entitled Méthodes et outils de mesure reliés à la productivité. This latter document is specifically intended for practitioners in productivity measurement and provides them with a description and an evaluation of a number of measurement tools. The present report takes the form of considerations aimed at a public of researchers, managers and consultants in the field of office automation systems evaluation.

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1. Introduction

1.1 The service sector now plays a dominant role

The economies of industrialized countries are increasingly dependent on the service sector. In the near future, "service industries" will employ five to eight times as many people as all other sectors combined.

A recent American study predicted that employment in the manufacturing sector would drop from the current level of 25 percent to only 5 percent of the labor force by the beginning of the next century, and the primary and secondary sectors together would account for only about 10 percent of the working population.

The manufacturing sector, which produces goods, would be reduced to a proportion similar to that of agriculture. This does not mean that these sectors are declining, but rather that they generate significant gains in productivity which open the way to new activities that are mainly linked to the service sector.

Historically, economic wealth resulted from the production of raw materials and finished products. Even in 1987, most programs of government aid to business are limited to these two sectors of the economy. The service sector has traditionally been seen as providing "support" to the other sectors. This has led to a veritable social "syndrome" that can be clearly seen in many disciplines. "Overhead" or "administrative expenses," which in accounting of manufacturing companies includes expenses for such services as management, marketing, purchasing, research, transportation and legal counsel, is an example of this; these administrative costs are seen as expenses that support the main activity of production. Even when management activities become more important than production, the practice of considering these expenses as "indirect" or supporting persists.

The service sector is also undergoing far-reaching changes. In a recent study, the Economic Council of Canada (Betcherman and McMullen, 1986) notes that, in the period 1980-1985, white-collar workers were the most affected by the introduction of new technologies. These changes were not

evident in employment statistics, and thus went unnoticed. Paradoxically, while it was in offices that the concepts of industrialization (Taylorism) and improvement of productivity in the primary and secondary sectors were developed, the wheel has now turned, and these industrial processes, appropriately or not, are being applied to the service sector. Industrial production methods are used as a model, tasks are standardized and made repetitive. This is the type of work that Crusec (1985) calls "procedural." Others speak of the service "industry," since these activities do not differ greatly from those of the manufacturing sector: production is standardized and outputs can be counted.

1.2 ... and is dominated by white-collar workers

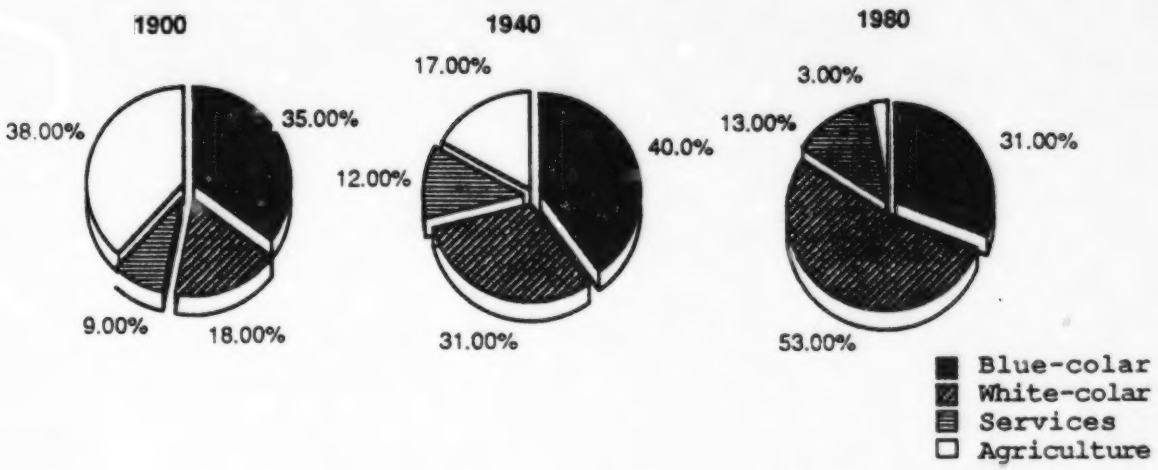
The service sector is not made up only of office workers. Its diversity (army, public servants, merchants, janitors, hairdressers, etc.) is no doubt the reason why so little research has been done on it, and why the literature tends to confuse the service sector with office work. The two are not entirely synonymous: of the 70 percent of the work force employed in the service sector, two-thirds are white-collar workers.

The Diebold Group (1982) predicted that more than 50 percent of the working population would be employed in offices - workers involved in information and information transactions - by the year 1990. Today, in 1987, this figure has already been reached, and over 75 percent of salaries are paid to white-collar workers. We do not have similar statistics for Canada, but we cannot imagine that we would be very different from our American neighbors. A number of studies mention the fact that 50 percent or more of the Canadian labor force is employed in information-processing activities (in the broad sense).

Chart A

Structure of changes in the labor force

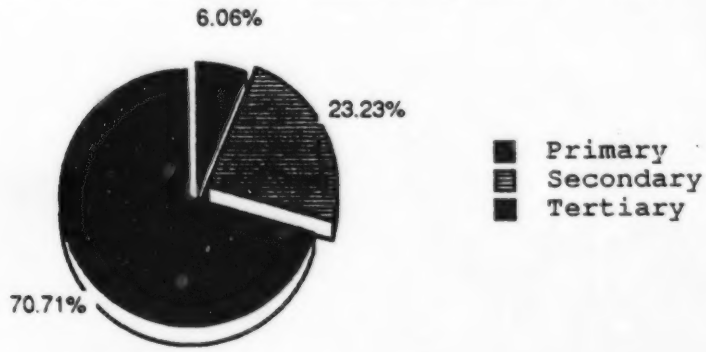
in the United States



Source: 1900, 1940; U.S. Department of Commerce, Historial Statistics - Colonial Time to 1970, Series D, 182-232 and 1980 U.S. Departement of Commerce, Stat., Abstract of U.S. 1981

Chart B

The labor force in Canada by sector, 1986



Source: Statistics Canada, Cat. no. 71001, 1986

1.3 Productivity: high standard of living

If economic growth is to continue, it is imperative that productivity across the nation continues to increase. This growth was particularly evident in the primary and secondary sectors throughout the last century. Although productivity in these two sectors was offset by an increase in service expenses, industrial countries enjoyed continuing economic growth. To ensure national productivity growth, greater efforts must be expended in the tertiary sector of the economy between now and the turn of the century.

Over the past decade, productivity in this sector grew by only 2 percent compared to over 20 percent for the other sectors. The cover page of the May 26, 1986, issue of Fortune Magazine read, "Business has spent billions, but white- collar productivity hasn't budged." This was unwarranted, since there was obviously confusion between the tertiary sector and office work; once again, figures for the service sector (since these do exist) were taken as figures for white-collar workers, for whom there are no statistics.

This small increase in productivity is often explained by the low rate of investment per office worker (Katambwe, 1986). Businesses invest only $1 per white-collar worker where they invest $15-$20 for every blue-collar worker (Zisman, 1987; Ader, 1984).

Although minimal compared to those of the manufacturing sector, investments are made in office technology and are justified on the basis of objectives of which the most important (for decision-makers) is an improvement in productivity, which provides a cost/benefit justification. One thing appears certain: we must be able to evaluate and measure in order to manage. Office technologies have manifold and complex effects on persons, groups, organizations and society. By the turn of the century, 80 percent of workers will be affected by office technologies. It is important that we have measurement tools that can assess their impact on productivity at all

these various levels. As **Dean Meyer** stated recently (1986), "OA is not a blank cheque anymore, it has to be justified by ROI!" Measurement is necessary to justify a product, to justify or render credible a budget at the strategy level and to "sell" a project based on the success of a previous one.

> To improve productivity, you must manage
> To manage effectively, you must control
> To control consistently, you must measure
> To measure validly, you must define
> To define precisely, you must quantify.
>
> (From **Doane Raymond**, "Productivity Measurement" Seminar)

1.4 Purpose of the study

The purpose of this report is manifold. It presents the results of research and reflection by an Organizational Research Directorate task force at the Canadian Workplace Automation Research Centre, which looked in particular at productivity measurement in an office automation environment. The approach used involved producing an international bibliography on the subject, preparing a critical review of the literature, creating an informal "ad hoc" network linking some one hundred researchers in Canada, the United States and Europe, and, based on readings, formal and informal contacts and conferences, to produce this document which attempts to give a brief summary of what productivity is and to describe the various approaches and schools of thought. It is also intended to provoke reflection among managers responsible for implementing office automation in their organizations.

2. Productivity and Office Automation

2.1 The office has less body ... and more soul

Before taking a closer look at what office automation productivity might be and how it might be measured, we should first identify the various elements

of an office, along with its operation, activities and environment. The dictionary defines an "office" as a physical location where businessmen or the employees of an enterprise or organization normally work. A more general and generally accepted definition seems to be the notion that an office is an organized group of workers. It is, to some extent, a cell of the organization with a common activity linked to a given function. An office thus exists to fill the very specific needs of the organization. Trist (1981) defined units of office work as systems performing a series of activities in an identifiable sub-system of an organization. The dimension of the office is small in terms of space and number of persons. According to Kalthoff (1981), the office is the nerve centre of any organization and a complex system made up of persons, tasks and information working together in an interactive and effective manner to achieve common goals.

In the space of a few years, we have thus gone from a very physical definition of the office to a much broader definition involving human beings, equipment, information and work methods. Although this definition recognizes the complexity of the office as a work unit and the fact that this work unit is organized, it is nevertheless incomplete. Information has become the main element of an office. This information may be handled using various tools, such as pencils, voice or computers. Some account must also be taken of communication, which has become an extremely important activity in information processing. While communication was traditionally an interpersonal activity, new office technology extends this "communication" to communication between humans and computers and also between computers.

With the emergence of new information technology, the office is now considered mainly as a system and only secondarily as a location. The office no longer has physical dimensions insofar as it might just as well be a hotel room, an airplane seat or a conference room as an office in the strictest and most traditional sense.

Moreover, in 1987, we are becoming less and less convinced that a clear dividing line can be drawn between office work ("white-collar work") and "blue-collar work". As noted by **Strassman** (1985), an increasing number of tasks formerly accomplished by physical work are now performed by computer and employees are increasingly involved in information processing. We are thus seeing a significant broadening of the concept of office work, ranging from telework at home to information processing on the production line.

2.2 Office automation: assistance to office work

For **Mintzberg** (1973), the principal activity of an office is to communicate information. This information, in addition to being communicated, must also be created, stored and processed. Personnel are required to process this information.

The volume of information available and to process has never been larger than at present. Since information is also synonymous with power, everyone needs to possess as much of it as possible (**Kalthoff**, 1981). We are forced to admit that our society has clearly entered the information age, concerned more and more with information and less and less with products extracted from the earth or manufactured. The time was thus ripe for the creation of a new term, "office automation."

Pierre Ardouin (1986, 2) notes that "office automation" is a current buzzword, yet many people use it without defining it. In the narrow sense, he sees office automation as another application of computer technology, while under a broader definition it is a new field, encompassing computer technology and information systems. The AFCET (Association Française de la Cybernétique Économique et Technique) has proposed an interesting and quite complete definition: "Office automation is the assistance to office work procured by methods and procedures making use of computer technology, telecommunications and administrative organization and, in a general manner, all

that contributes to the logistics of an office and its environment." Office automation is thus a body of techniques to assist a person with office work, by helping him produce and communicate (Poliquin, 1985).

It seems obvious that, for any organization, the astronomical amount of information handled has become a serious organizational problem. Information handling can considerably increase the costs of a business, and this is a powerful motive for finding ways to reduce the costs incurred in this activity (Poliquin, 1985). One solution lies in increasing productivity in office-related activities. Here as well, some ways of measuring productivity, no matter how imperfect, should be developed, since activities that are not measured cannot be controlled.

2.3 From production to productivity

The terms "production" and "productivity" are closely linked. For the Petit Robert, the word "production" has been in existence since 1283, and the word "productivity" first occurred in a document dated 1766, with the latter term being derived from the former. Thus before we examine productivity itself, its definition and method of calculation, we feel it would be well to review the question of production.

2.3.1 Production

For Thomas Suavet (1962), production is the "act of producing"; it is also "the quantity of objects produced during a production cycle or in a given time period." As well "production capacity is the number of units that a plant or business could produce if equipment was used to the fullest." It will be noted that these definitions concern only the primary and secondary sectors. Factors of production, again according to Thomas Suavet, "are those elements which combine to permit production, basically human labor and capital." He does note that there is a third factor: for some, it is the stock of accumulated knowledge and technical progress, while for others, it is organization.

Given these definitions, we can better understand the problems of economists studying office production: the term "production" was for centuries applied only to perfectly quantifiable, tangible material goods and the factors of production were basically reduced to human labor and capital alone.

More recent dictionaries and encyclopedias, however, define production as "the process of creating economic goods, including material goods and personal services" (Encyclopedia Americana, 1977).

Looking back in time at the history of economic thought, we can see that a similar definition probably evolved in the 17th or 18th century. This was the mercantile period: Spain and Portugal were stockpiling precious metals, France was exporting manufactured goods, and the Dutch and English were attempting to build up a trade surplus by exporting not just merchandise but also services such as transportation, brokerage, stock markets and commercial markets. The Dutch and the English were well aware that "national production" includes services as well as goods. But these ideas were not destined to last.

The 18th century physiocrats spoke of the sterile nature of industry and trade. Their "natural and universal law" was timeless and thus rejected the notion of history. Wealth (and production) came only from the soil. Quesnay stated that the role of capital was the accumulation necessary to increase production, thus founding the concept of "gains in productivity." His ideas were to mark the whole of classical economic theory, and consequently shape the definition of "production" for generations to come.

The classical economists such as Adam Smith and John Stuart Mill studied not only agriculture and extractive activities (Quesnay), but also manufacturing activity. In the 19th century, the Austrian School led by Carl Menger developed a theory of goods that defined them as anything able to satisfy a human need and available for that purpose. The concept of production was thus once again broadened to include services such as transportation, trade, marketing and repairs. The 20th century has seen no

notable evolution in the theories of production. Some economists define production in the broad sense, while others do not seem concerned with the matter at all. There are the partisans of "measurability" and those who believe in the contribution of the social sciences (anthropology, history, psychology and sociology).

2.3.2 Factors of production

As regards the factors of production, the Americans have shown the importance of enterprise as a factor that must be added to capital and labor. Enterprise is the activity of initiative and innovation that organizes the other factors of production.

Production of goods entails marketing and administration costs which are added to production costs per se. Throughout this century, managers have endeavored to reduce production costs, since they could easily measure and quantify production and use well-established production control and time and motion study techniques. Managers may be said to have succeeded remarkably well in controlling costs in the primary and secondary sectors (production and processing) using new techniques, and in doing so have improved productivity in these sectors. The marked improvements in productivity in these two sectors were, however, offset by an increase in "tertiary" expenses, which included such things as the costs of finding and creating new markets and the costs of distributing products.

Economists and accountants have determined the costs of production in considerable detail, and cost accounting has been developed and refined over the past decades; however nothing has as yet been written on office production. The word "production" thus remains, even today, a term mainly associated with the primary and secondary sectors.

2.3.3 Total productivity

A review of the literature shows that productivity is linked to various concepts: efficiency, effectiveness, performance, management, analysis, input-output, yield, etc. The fact that writers in many different fields use the term "productivity" is some indication as to why there is no universally accepted definition of productivity in the literature. Productivity is nevertheless defined by the Petit Robert (1984) as "the ratio of product to the factors of production." It is also defined as "the quantity produced in relation to labor supplied and expenses incurred" (Larousse, Lexis, 1977). The Petit Robert (1986) provides a more complete definition, "a measurable relationship between a given production and all factors brought into play (overall productivity) or only one of these factors, for example, manpower (labor productivity)."

Since productivity is the ratio of production obtained to the means used to obtain it, the numerator of this ratio will be the result obtained and the denominator the total of all the efforts exerted to obtain this result. The example of the productivity of a fruit tree shows how difficult it is to measure actual productivity. While it is relatively simple to make the numerator the number of apples picked (or their weight or value), the denominator will include such varied items as time spent harvesting, the work of planning, care of the tree, quantities of fertilizer, herbicides and pesticides and the cost of land. This productivity is all the more difficult to measure when the quality of such elements must be considered.

It is because of the problems involved in measuring real productivity that economists very often prefer to study variations in productivity. Increasing productivity thus means obtaining better results, either in quantity or in quality, without increasing the means utilized and/or to obtain the same result while reducing the means.

All other things being equal, if input to the system does not change while output increases, productivity will increase accordingly. If input increases and output remains unchanged, productivity decreases.

Advantages:

- model tested and mastered in primary and secondary sectors
- gives a complete picture of productivity
- allows comparisons between organizations of the same type
- may be used in tertiary "industry"

Disadvantages:

- according to many, does not take into account the process (transformation of input into output which includes variables such as human resources)
- complex when applied to office activities

2.3.4 Partial productivity

Another type of productivity measure, known as partial productivity, is the relationship of the total of all "outputs" to a single type of "input" instead of all inputs combined.

Partial productivity = outputs / 1 input

We can thus speak of capital productivity, productivity per capita, etc. This partial measure is very commonly used and, as we will see further on, often abused. The calculation of production with respect to a single factor of production is closely related to the concept of yield. Even in the 19th century, early estimates of productivity in the United States were made in terms of "labor productivity," by examining only the ratio of outputs to the input "labor." The concept is still used for the "labor statistics" produced by the U.S. Department of Labour as well as by the statistics offices of all industrialized countries.

Production per hour and other measures of partial productivity are often used in comparisons between countries, provinces, regions or industrial sectors. These partial measures also provide a satisfactory and comprehensive image of growth in productivity in relation to a given factor of production. They nevertheless are significantly biased in that the other explanatory variables are not monitored. Thus, when labor productivity increases, we do not know whether this improvement is due to workers, capital, management or financial considerations.

> ...it must be kept in mind, nevertheless, that "partial" measures, for example labor productivity measures which relate output to labor time utilized, do not measure the specific contributions of labor or any other specific factor of production. Rather, they reflect the joint effect of a number of interrelated influences, such as the variations and changes in management skills and practices, technology, capital investment, specialization... or the skills and effort of the work force. (Bernolock, 1980)

Advantages:

- tested model
- ease of use

Disadvantages:

- significant bias due to:
  - . single variable (as input)
  - . no control or inclusion of other explanatory variables
- model incomplete
- establishes little or no causality

2.4 Value added

Value added refers to office automation applications that concentrate on organizational efficiency. Measuring it allows us to calculate the impact of office automation on the efficiency of the organization. It is measured using certain management techniques such as present value and the rate of return on investment (ROI).

Advantages:

- ease of use
- eliminates or decreases systematic bias and errors
- permits calculation of productivity growth

Disadvantages:

- does not permit absolute measurement of productivity
- does not permit very valid comparisons between organizations, regions, countries, etc.

Dean Meyer (1986) is probably the most fervent proponent of the value-added method. He simply calculates the present value of gains due to a new application less its costs; the result is the "added value." The method proposed by **Norman Archer** (1985) of McMaster University is much more rigorous. Based on the theory of information value (**King and Epstein**, 1983), he developed a multi-attribute model for measuring the value of each "information" product. His model has not yet been successfully tested, but this sould be accomplished by his research team during 1987.

2.5 Effectiveness

Effectiveness is a measure of attainment or realization of the goals of an organization; however, this notion is not very clearly defined in the literature. There are three main schools of thought: 1) productivity is a measure of effectiveness; 2) productivity includes both efficiency and effectiveness; 3) productivity and effectiveness are two separate but related concepts. It may be formalized as follows:

Effectiveness = O/S

where O = outputs

S = standard for outputs

We feel that effectiveness should be seen as a measure distinct from productivity for the following reasons:

1) It does not include inputs, the basic elements of productivity.
2) It implies an element of attainment of microeconomic/organizational objectives (S, standard for measuring outputs), eliminating any possibility of intra-organizational or situational comparisons. We must also reject the second trend mentioned above which defines productivity as outputs over inputs + outputs over standards, since this means double-counting the outputs (O/I and O/S).

The trend towards completing the definition of productivity by including effectiveness is followed by many psychologists. Tuttle (1983) recommends it for studying the improvement of organizational productivity.

Advantages:

- implies an element of goal-attainment
- ease of use
- easy to understand

Disadvantages:

- not a measure of productivity but rather of goal-attainment
- does not include inputs

2.6 Efficiency and yield

Efficiency is the measure of use of resources employed for the production of outputs, while yield is defined as the useful effect of an intellectual or manual worker, or more generally as the ratio of useful work to the quantity of energy employed. These two concepts are very similar and may be used synonymously.

Advantages:

- takes into account factors of production
- often easy to use
- appropriate for individual measurements

Disadvantages:

- incomplete measurements
- does not include outputs
- confuses work and the effect of work

In two recent surveys carried out by the Organizational Research Directorate of CWARC, **Bernier, Kishchuck and Légaré** (1986) and **Ardouin** (1986,1) observed that in the 60 large and medium-sized businesses visited, were all concerned with improving productivity. But for their executives (over 150 were interviewed during the two surveys), the main productivity measurement elements are reduction of expenses and savings in personnel time at various levels. This indicates that managers are more concerned with effectiveness and reducing the cost of the factors of production (inputs) than in increasing outputs. Is this a sign of the times?

2.7 Performance

Organizational performance encompasses a series of concepts, measures and indicators as varied as the concerns of investigators. **Sink, Tuttle** and **Devries** (1984), the directors of three regional productivity centres in the United States, have developed a model for performance measurement that uses seven criteria:

- effectiveness
- efficiency
- quality
- productivity
- profitability
- innovation
- quality of working life.

Although this model is statistically unsatisfactory, it does represent a whole school of thought mainly comprising industrial, organizational and social psychologists. In practice, this model involves too many variables to permit measurement. **Blake** (1987) suggests limiting calculations to measurement of effectiveness, efficiency and productivity.

3. Various perceptions of productivity

As we have seen, in purely technical terms, productivity is defined as a measure of outputs and inputs, expressed in units produced by units of factors of production.

It is interesting to note that, in 1987, productivity is a concept that is studied by researchers in such varied disciplines as accounting, engineering, management, economics, sociology and psychology. It is not, however, seen in the same way by all these researchers and workers. In an article in the American Psychologist, J.C. Tuttle (1983) describes these various approaches, and these are summarized below.

3.1 For the accountant

The accountant's role is to describe and improve the financial performance of organizations. Several financial ratios are used for this purpose, many of which resemble the output/input productivity ratios: profit/capital, sales/capital, sales/fixed assets, sales/stocks, sales/employees, profits/employees. Today's accountant uses these elements as a basis for diagnosing the productivity of the business. Cost analysis, a method used by engineers and accountants but developed by the latter, involves totalling production costs and applying them to each unit produced to arrive at the exact unit cost. The purpose of this exercise is to establish the cost of production. The problem with this method lies in the difficulty of allocating expenses and the time required to calculate the cost of production. A new method, developed to remedy this, deals only with variable costs. This is standard cost accounting, which charges to each unit the variable costs it creates, while fixed expenses are charged to total production. For the accountant, these two methods are closely linked to the concept of productivity.

In short, the accountant reaches a diagnosis of productivity using ratios.

3.2 For the manager

A study by **Katzell, Yankelovich, Fein, Ornati and Nash** (1975) shows that managers use a broader definition of productivity than accountants, economists or engineers. The productivity model they use includes efficiency, effectiveness, quality, work disruption, sabotage, absenteeism and personnel turnover. A similar study by **Ardouin** (1986, 1) on a sample of Montreal-area businesses demonstrates the problems managers have in defining the concept of productivity and their even greater difficulty in defining a measurement model. Their definition is very broad and vague. The results of a study involving managers in 10 large Canadian organizations (**Bernier, Kishchuk, Légaré**, 1986) confirms that managers have a very broad definition of productivity which includes the following factors: the business's profitability and market share; quantity and quality of products in relation to costs, effectiveness of the organization (organizational structure and job design); working climate and employee relations; customer satisfaction and the attainment of goals set by senior management.

3.3 For the engineer

The engineer's definition of productivity derives from the notion of efficiency, or the output of a machine, that is, the ratio of useful work to energy used. It is, of course, in the field of industrial production that productivity can most easily be quantified by the engineer. Inputs and outputs are clearly identified and measurable. Using methods and time and motion studies, the engineer, working with the accountant, develops ways to improve productivity. Since the industrial revolution, production costs have clearly been cut and productivity in plants increased through elimination of human work and its replacement by machines. Computer-assisted production (use of micro-processors in production) plays a major role in improving productivity in the last two decades of the 20th century. It is the engineer's "productivity," combined with that of the farmer, that is responsible for the current high standard of living in industrialized countries.

3.4 For the economist

The economist uses the basic production function Q=F(W,C,I,T), where Q is the quantity of outputs, W work, C capital, I intermediate products purchased and T time. Productivity, for the economist, is the relation that exists between outputs and inputs.

$$P = \frac{O}{I}$$

The economist confines himself to the O/I relationship, and very few of them would agree to extending the term to the tertiary sector.

3.5 For the industrial/organizational psychologist

The industrial/organizational psychologist's role is basically explaining human behavior in organizations. He also acts on this behavior, and on the organizational environment of human beings. Productivity defined as the relation between outputs and inputs is not a major preoccupation for the psychologist, who is mainly concerned with the input "labour." It seems fair to say that the psychologist believes that work performance is directly related to the satisfaction of the worker, whose needs must be satisfied to improve productivity. Tuttle (1983) recommended that psychologists become involved in organizational productivity studies, using the broader definition of efficiency and effectiveness.

There is a role for the psychologist in productivity management. According to Tuttle (1983), this includes five stages:

1) developing productivity awareness;
2) data analysis to develop strategies to improve productivity;
3) planning productivity goals in the short, medium and long term;
4) implementation, which may involve restructuring employee organization, introduction of new technologies, greater employee involvement in the decision-making process and changes to job descriptions and work procedures;
5) assessment to determine the success of the organizational changes.

It was through the individual that psychologists gained entry to the organization where they are now also concerned with groups and the organization itself. Their measures nevertheless remain essentially partial, and deal only with the efficiency and effectiveness of individuals and groups and with the quality of working life.

3.6 Summary

We may say that accountants and managers compare output/input ratios with the standards and ratios of other organizations, engineers calculate how changes in production methods may affect volume of outputs, economists measure the goods-producing capacity of a system and psychologists develop organizational effectiveness strategies based on the quality of working life.

Improvement in productivity is impossible using just one of the approaches mentioned above. Only an approach influenced by all of these disciplines will be able to resolve the problems of productivity management.

3.7 The macroeconomic view

At the macroeconomic level, productivity is often associated with labor productivity. The Economic Council of Canada (1985) prefers the broader notion of "global productivity of factors" (GPF), which is the indicator of a better use of the factors of production. The Council states that the following factors influence macroproductivity:

1) mobility of resources
2) composition and quality of manpower
3) capital and advanced techniques
4) economies of scale
5) use of production capacity.

To increase national productivity, the Economic Council of Canada recommends increasing market efficiency by strengthening competition through regulatory reform and encouraging healthy expansion of trade. These recommendations make very little mention of new technologies, although;the Council, in its 23rd Annual Review (1986), does mention adopting new techniques as one factor that would bring increased productivity by 1996.

4. Approaches to measurement

There is no existing theory of white-collar productivity (Diebold, 1982), but there are several approaches or models for measuring office productivity. We can distinguish three main approaches: one based on activities and tasks, one derived from economic models and a third based on the participative and/or normative approach.

4.1 Office activities approach

This approach is very important in the field of productivity due to the applicability of its methods (Blake, 1987). The firm of Booz Allen and Hamilton has developed, for study purposes, a method that makes it possible to examine how managers and professionals use their time. They were thus able to observe that these persons spend 25 percent of their time on the average doing work that is termed non-productive.

Sassone and Schwartz (1986) use a similar approach; however, their method also permits assignment of a financial value to changes in time allocation due to office automation.

Here in Canada, the research group led by Daniel Pascot (Laval University) may be considered as the most advanced in the development and application of a method of measurement based on office activities and tasks. Pascot (1986) has developed a conceptual framework for the evaluation of productivity in office automation. In 1987, his group began implementing and testing this model.

Criticism of this office-activities based approach includes the following:

- This approach does not measure productivity at the organization level, but instead measures effectiveness.
- It does not calculate the contribution of office activities to the missions of the organization; in other words, it assesses effectiveness (inputs) and the process. Outputs, or the products of professional and management work, are ignored in this type of model. Only human labor, one of the factors of production, is assessed.

4.2 Economic measurements

The model developed by the American Productivity Center is a good example of the traditional economic approach to productivity measurement. The APC basically examines two dimensions in its productivity diagnoses: productivity per se (ratio of outputs to inputs) and the cost of production. In many cases, the APC uses partial productivity measurements rather than an overall measure when it is particularly difficult to identify output and input variables. The APC (and its methods) appear to have a good reputation among large multinational corporations, but little credibility among recognized researchers in the United States.

Closer to home, Pierre Ardouin (1986, 2), also at Laval University, has for some years now been studying the problem of measuring productivity related to office automation applications. His method bypasses or avoids the problem of identifying office outputs, which is a stumbling block for most other models. His model analyses the costs and benefits of each computer application for all sectors of the organization, thus enabling him to calculate a series of value-added indicators for each computer application and for all applications combined. One basic (although questionable) assumption of his method is that managers in the various sections of an organization are capable of assessing the value of a computer application for their section. The model has already been successfully applied to the whole

range of systems of a large company. **Pierre Ardouin**'s group is now refining the model and is currently using it to evaluate the computer systems used in a large public-sector organization.

4.3 Participative and/or normative approach

This approach is termed participative and/or normative because all the methods linked to it essentially encourage those concerned to participate in the development of indicators or standards for measuring productivity.

This approach is dominated by the Nominal Group Technique (NGT) developed by **Delbecq** and **Van de Ven** in 1968. First used in problem-solving, priority-fixing, resource allocation or as a planning tool, the NGT is now used to identify opportunities for improving productivity and developing measurement tools for productivity (**Gregerman**, 1981).

This method uses groups of employees (8-12 per group) to select productivity factors as well as measurements (Conn, 1984). The process is organized in such a way that no individual can dominate or influence the group. More specifically, the members of the group are asked by a consultant to draw up a list of methods, ideas or solutions that would enable them to perform better (be more productive) and be more satisfied with their work. They are also asked to indicate how all this should be measured. The consultant (or resource-person) meets with all participants individually, at which time they can explain their ideas to him. This is followed by a group session to make sure that all participants have a good understanding of each of the solutions proposed, as well as of the objectives of the program. At this time, the group may decide to drop, revise or combine some of these ideas. No evaluation is permitted at this stage. The next step is the vote, whereby each participant chooses a certain number of ideas (for example, five), which he ranks from first (best) to last. Once all the results are in, all participants discuss and evaluate the solution chosen. The voting may be repeated if this is felt necessary.

The NGT has considerable potential for developing tools (methods) for improving and measuring productivity (**Devilliers**, 1980). It may be applied to all types of organizations. Moreover, participants need not be extremely knowledgeable about technology; they simply need a good understanding of the work involved. By encouraging the participation of workers, the NGT helps foster the development of a feeling of involvement and commitment.

The Common Staffing System is another method that adopts the line of thinking of this approach. With this system, the units under study participate in the development of indicators. In the case of IBM, these units are its subsidiaries. This method makes it possible to compare the productivity of several similar units over a given time period.

The main drawback to this method is that it does not allow comparison between different units (organization, department, individual, etc.), nor analysis of the contribution of each unit to the overall productivity of the organization.

5. Conclusions

5.1 The basic problem is conceptual

1. There are fundamental differences between blue-collar and white-collar work. However, within organizations, and even at the macroeconomic level, there is a tendency to apply to the office environment methods of evaluation specific to the primary and secondary sectors of the economy.

Roger Nesme, very aptly quoted by **De Blasis** (1982), has drawn up a comparison table (reproduced below) which clearly illustrates why it is difficult to measure productivity in the office. While it is relatively easy to calculate these measurements in the primary and secondary sectors, it is relatively complicated to do the same for tertiary activities.

	PLANTS	OFFICES
PRODUCTS	- Concrete - Homogeneous	- Abstract - Many special cases
METHODS OF OPERATION	- Structured - Standardized - Few useless tasks	- Empirical - Many useless tasks
MATERIALS EMPLOYED	- Mechanization - Automation - Costs known	- Mechanization almost non-existent - Low degree of automation - Costs unknown
SCHEDULING	- Operating time measured - Charges known	- Time not measured - Poor knowledge of charges
QUALITY OF WORK	- Quality level defined - Rejects admitted - Quality control	- Notion of tolerance unknown - No rejects - Control not consistent (negligent to perfectionist)

2. Since concern with measurement is multidisciplinary in nature, a generally accepted definition of productivity is lacking, and there is considerable confusion between terms such as productivity, effectiveness, efficiency, yield and performance.

3. Given the difficulty of rendering concepts operational in an office environment, there are differences between theory and its application.

5.2 The five questions that must be asked (Q5/W5)

5.2.1 Why measure? what are the goals of measurement: program evaluation, competition, expansion, rationalization, quality of working life, planning, human resources, control, etc.

5.2.2 What to measure? activities, products (shipped and/or in inventory), procedural and/or non-procedural, measurable and non-measurable, decision-making, etc.

In productivity measurement, outputs are shown in the numerator of the formula and include goods and services produced during the observation period, using the factors of production (inputs) shown in the denominator of the same formula.

While it is fairly easy to measure inputs, the difficulty increases when we wish to measure outputs (Kishchuk, et al, 1986). As opposed to the industrial worker, the office worker does not make a clearly defined product. Moreover, this undefined product is not necessarily delivered during the same period in which the inputs are used. In addition to processing some data immediately, the office worker stores data for future use. He might almost be seen as an autonomous processing facility: raw material flows in, processing takes place, finished products leave, but the raw material (data) and the finished products (information) may be carried forward to a later time.

In addition to measuring production during a given period, we must also consider the information "inventory" at the beginning and end of the period in order to arrive at a complete model like those developed for the secondary sector. This is a very difficult or nearly impossible task, since we must periodically measure the "information" content of the brains in the organization and in other written and electronic memories.

5.2.3 Where to measure? at the individual level, the group, the organization, or at all three levels?

If the goal is to develop an office-productivity measurement model to calculate productivity gains due to the introduction of office automation, we cannot measure changes in productivity for each individual in isolation and draw conclusions from these individual results. The goal of the organization is to measure the overall improvement in productivity or an improvement in the departments involved in the case of a pilot project.

Drawing conclusions on productivity improvement using measurements taken on certain specific groups within the organization must also be rejected: this type of analysis is not relevant to the entire organization, since it does not justify investment in office automation. An investment that is justifiable for one department may not be valid for the whole organization if it does not improve the productivity of other departments.

The only acceptable measurement thus remains that of improvements in productivity in the organization as a whole. Notwithstanding the rejection of conclusions based solely on individual or group measurements, measurements of organizational productivity are determined by four main components.

where $P_{tot} = f(P_{ind}, P_{gr}, P_{org}, P_{ext})$

P_{ind} = sum of individual productivities
P_{gr} = sum of group productivities
P_{org} = organizational productivity
P_{ext} = contribution of external office automation (in other organizations) to the productivity of the organization

It appears that individual productivity does not increase significantly with the introduction of office automation and may even decline temporarily in certain cases. Gains in productivity will be more apparent at the group or organization level.

5.2.4 How to measure? partial or global model, additive or multiplicative model or a combination of the two, value added, active or passive observation, monitoring, questionnaires or interviews.

A purely additive type of model should be rejected for use in any measurement of productivity. Let us take the example of a simple model which is often used to measure productivity: P = quantity + quality. This model would give P a positive value, perhaps even a high value, if the quantity is high, even though quality may be nil. This model should be rejected and replaced by quantity x quality. Psychologists, in our opinion erroneously, use many additive models in their assessments, whereas in the majority of cases a system functions in a multiplicative manner. This additive rather than multiplicative vision is, in our view, the cause of many failures in various types of activities (interviews, evaluation of candidates, bidders, hardware, software, systems, etc.). The more integrated a system is, the more likely we are to be dealing with a multiplicative model.

5.2.5 Who measures? internal or external to the organization, to what school of thought does the "measurer" belong, is he an interventionist?

5.3 Approaches to method selection

The matrix in the table on the following page shows measurement objectives in relation to levels of application. We may thus seek to measure (objectives) total productivity, partial productivity, efficiency, effectiveness, value added or performance. There are four main levels of measurement (units of analysis): the organization, the department, the work group and the individual. As a general rule, a work group is made up of 2-10 people, while a department

contains 10 or more people. If an organization has a department of only six people, we would speak of a work group. Conversely, if a work group has over 25 members, we would speak of a department.

Objectives / Level	Total Productivity	Partial Productivity	Efficiency	Effectiveness	Value Added	Performance
Organization	*	*		*	.	*
Department				.	*	.
Work group	.	*		*		
Individual			*	.		.

* : Most suitable analysis unit

. : Potentially suitable analysis unit

The next table provides the reader with the level of application of the methods discussed in this document. It should be noted that the "value added" of **Dean Meyer** refers to the method he developed for measuring value added.

Objectives / Level	Booz	D.P.	S.&S.	P.A.	APC	V.A.	CSS	NGT
Organization				.		.		
Department	.	.	.	*		*	.	.
Work group	*	*	*				*	*
Individual	.	.	.					

Key

Booz	:	Booz Allen & Hamilton method
D.P.	:	Daniel Pascot method
S.&S.	:	Sassone and Schwartz method
P.A.	:	Pierre Ardouin method
APC	:	American Productivity Center method
V.A.	:	Dean Meyer's value added method
CSS	:	IBM Common Staffing System
NGT	:	National Group Technique
*	:	Most suitable analysis unit
.	:	Potentially suitable analysis unit

5.4 Limits to measurement

Despite the major problems involved in measuring productivity in office work, most authors feel that any program, new application, use of new technology or even an individual should be evaluated. This is the first step in any systematic attempt to improve productivity. This exercise does not, in fact, consist in rejecting measurements, but rather uses them while bearing in mind their strengths and their weaknesses (Siegel, 1986).

Use of a productivity measurement system in an organization is only possible in the presence of favorable factors such as creative leadership and employee confidence. These factors are often part of the new organizational cultures in which employers and employees combine their skills and knowledge in a creative effort to keep the organization competitive.

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Appendix 1

Productivity Measurement in the Public Sector

Since 1960, the growing place occupied by public-sector organizations in the economy has brought economists, managers, sociologists and other groups to look more closely at this sector and the productivity problems affecting it. This growth has led to the creation of several agencies whose specific role is the measurement and efficient management of performance in public administration. The National Commission on Productivity in the United States is one example. In Quebec, concern was first expressed on this question by the Bisaillon Commission (special commission on the public service) in 1982 (Gascon and Martel-Roy, 1982).

Productivity is a concept that originated in the private sector. It is traditionally defined as the relation between goods and services produced (output) and the resources used to obtain these (input). Ayres and Kettinger (1983) discuss several conceptions of government productivity. Some authors refer to effectiveness and place the accent on government programs and their effects on society, while others emphasize operational measures, which deal with labor. The most commonly used definition is based on the output/input ratio, which is know as "effectiveness" in the literature on public administration.

We cannot discuss productivity without referring to the measurement problem associated with it. Measuring productivity is a challenge which many organizations and researchers have attempted to meet. In the case of the public sector, the problem of measuring productivity is dramatically increased as the units analysed become larger and more complex. Units of analysis may vary depending on objectives. We may thus seek to measure the productivity of an individual, an office, a program, a department or the government as a whole. The difficulty with the unit of analysis stems from the fact that the larger and more complex this unit is, the more difficult it becomes to isolate costs and allocate them to specific goods or services produced.

The necessity of measuring quality as well as quantity is generally recognized and accepted in the public sector, even if in practice this is not always possible. Results may be biased if the emphasis is only on the

quantity aspect. For example, a section might increase its production while reducing the quality of its product and, in such a case, there would be no improvement in productivity. Conversely, if this section's production remains constant and of better quality, then productivity has been improved.

Ellen Doree Rosen (1985) discussed a formula for measuring productivity in the public sector. Rosen added a factor K to the Output/Input ratio to deal with the problem of quality. The formula thus became P = (KO)/I. She defines these variables as follows:

1. The input measure (I) represents resources: labor, equipment, space, materials and capital. Labor is normally the most important resource in the public service, accounting for 70 percent of costs according to Belanger (1981), and is measured in time/worker.

2. Quantity output is measured through the number of units of services or activities produced within the organization. Normally, neither the internal process nor the resulting revenue are measured.

3. The quality output measure is made up of indicators. For each, a standard or desired level is chosen. Based on this, the K factor is calculated for each indicator. These K factors are weighted, aggregated and combined into an total quality ratio that generally varies from 0 to 1.

Rosen's formula is interesting; however, we do not yet know whether it is applicable nor whether the results it produces are valid.

To the quality problem may be added the one caused by quantification of output, and this may sometimes be extremely arduous to solve. We have only to try to imagine the outputs of a government department. Ayres and Kettinger (1983) suggest we accept the fact that some government services are not amenable to productivity measurement. The problem of aggregation in departments that have service-producing agencies may occasionally be insurmountable.

Notwithstanding measurement problems, productivity can and must be improved. A number of solutions have been proposed for this, such as MBO (Management by Objectives), quality circles, profit-sharing or consultative management. All these solutions may be applied both in the public and private sectors. There is also a method that is exclusive to the public sector and that enables it to improve its productivity. This consists in leaving the task to the private sector. If it is possible to offer the same services, of equal quality at lower costs, productivity is improved. A study by Barbara J. Stevens (1985) on 20 cities (10 producing services themselves and 10 operating with private-sector contracts) showed that it is less costly for cities to contract work out to the private sector than to produce these services themselves. Eight municipal services were examined in this study, as shown in the table below.

With the exception of payroll, it clearly costs less for cities to grant contracts to the private sector for services of equal quality. An obvious parallel can be drawn from this study for the two other levels of government (federal and provincial). It would clearly be more advantageous for these levels to contract work out to the private sector in certain cases than to produce the services themselves.

	% difference (mu-co)/co*
Street sweeping	43%
Janitorial	73%
Refuse collection	42%
Payroll	0%
Traffic signal maintenance	56%
Asphalt overlay construction (repair)	96%
Turf maintenance	40%
Street tree maintenance	37%

* Average municipal costs (MU) less contractor costs (CO) divided by contractor costs.

Another case study shows that the consultative management approach is particularly efficient when properly implemented. This approach enabled the U.S. Copyright Office to absorb a 23 percent work surplus and a 19 percent staff reduction in five years while increasing productivity by 15 percent and saving the American government over $5 million (**Reed**, 1984). There were also gains in the areas of absenteeism, staff morale and employee desire to accept increased responsibility. Briefly stated, this approach consists in greater employee involvement in the decision-making process and a better definition of their duties and roles within the organization. Under this approach, employees are more highly motivated, more responsible and more dynamic.

How are we to know if productivity has increased if we cannot measure it? This question leads us to look at measures themselves. **Ayres and Kettinger** mention two types of measures: labor productivity or partial factor productivity and total factor productivity. These two types of measures are very commonly used in the public sector to calculate the effects of information technology on productivity. The first type compares output units with the labor input. This input is taken as the number of person-hours or the cost it creates. The second type compares output units with the cost of all inputs including labor, capital, energy and facilities. For **Ayres and Kettinger** (1983), total factor productivity is the better measure for calculating the impact of information technology on productivity. It is risky to concentrate on the input labor alone (first type), since information technology may well increase labor productivity without having the same effect on total productivity. In other words, information technology may very well increase labor productivity while decreasing that of other factors (capital or energy) and vice-versa.

Productivity is a very serious problem in the public sector. This sector is costly to taxpayers and has a very poor reputation for productivity in the eyes of the general public. Since the Canadian government is the largest

employer of white-collar workers in the country and also the largest purchaser of office automation equipment, it is logical for the Canadian Workplace Automation Research Centre to concern itself with this problem and propose productivity measurement models that will enable expertations regarding office automation to be verified and to improve and justify future information technology choices.

Appendix 2

An Example of the Use

of Productivity Measurement Indicators

This appendix is an excerpt from a document describing productivity measurement concepts examined in a pilot project for automation of forms. This experiment in office automation is being carried out by a team under Professor Louis Martin of the Université du Québec à Montréal. The forms automation and electronic mail project is being carried out using the electronic mail network linking the head office of the Fédération des Caisses Populaires de Richelieu-Yamaska and five of its affiliated credit unions. This project looks at three aspects of forms automation: impact on the quality of working life, effects on total productivity (there is no plan to measure individual productivity) and how technological change is introduced.

Those involved in the project see productivity as a factor that benefits both the organization and its employees in a number of ways. It makes for improved quality of working life and, because traditional productivity measures often cause working conditions to deteriorate, measurement tools must accordingly be adapted. It should also be noted that, in the context of this project, productivity basically consists in improving the quality of content and reducing transmission time. The researchers intend to assess productivity before and after forms automation. It was decided that this assessment would comply with the following principles: 1) no time and motion study would be performed; 2) individual performance would not be evaluated; and 3) the aim would not be to obtain more with fewer workers.

Measurement and evaluation indicators

This chapter discusses the various criteria for productivity measurement that might be used in carrying out this research project.

We know how difficult it is to measure productivity in "knowledge workers," as Paul Strassman terms them. New approaches have, however, been developed, and we will attempt to implement these in the context of this project.

In this chapter, we have chosen quantitative and qualitative measures of productivity that are appropriate to the requirements of our study. We have

chosen a combination of these two types of measures, since the use of one alone would skew the result.

Our project has certain very specific characteristics, and these necessarily guided our choice of indicators.

1) The project deals with a series of well-defined tasks, those connected with the processing and transmittal of forms. These tasks are, so to speak, isolated from all other tasks for the purposes of this project. We thus eliminate all measures that apply to the whole series of tasks performed by a given employee or to the working environment as a whole.

2) These tasks are of the procedural type, which implies the possibility of using quantitative measures to assess the impact on productivity without neglecting the qualitative aspect.

3) The aim of the project is to assess the effects of forms automation and electronic transmittal. Our productivity hypothesis will by confirmed or invalidated by comparing measurements or a series of productivity factors before and after automation. We must nevertheless take into account the costs connected with training and software development as well as the reinvestment of any time saved through automation and electronic forms transmittal:

> In relatively small investigations of the productivity impacts of office automation, probably the best that can be done is a careful accounting of all possible changes in inputs and outputs associated with the intervention, keeping in mind that the objective is to tie those changes to total organizational performance. (Kishchuk, 1986)

4) Because our definition of productivity is based on the profitability of an activity, and in accordance with our concern with quality of working

life, we have rejected measures aimed at assessing individual productivity. If it appears necessary, due to the geographical distribution of employees involved, in the pilot project, to adopt measures of individual productivity, these will not appear as such, but will be analysed on the basis of the experimental group.

We will distinguish indicators applicable to automation of forms from those that apply to transmittal by electronic mail systems.

INDICATORS USED

Forms automation	Electronic transmission
before - after measurements	
- **quantity:** rate of errors or omissions, number of anomalies, claims, etc. - **profitability:** production costs - **time:** processing - **quantity:** number of forms processed - **delays:** for signature or approval	- **time:** transmission - **profitability:** transmission circulation costs - **delays:** availability of equipment
+	
- training time and cost - cost of developing software - cost of any new equipment required - reinvestment of time saved: identification of new tasks and their profitability where applicable	

In the summary table below, we compare the list of possible productivity measures with the measures chosen for our project.

SUMMARY TABLE

Productivity measures	Measures used
A) From the economist school	
1) total production	too complex and too vast for our study
2) partial production:	
- capital	does not satisfy the goals pursued
- production/hour	because of the sporadic nature of work related to forms, we prefer to use specific ratio measures
3) multifactor production:	
- measurement by network	involves entire working environment
- performance system	not relevant
- comparison between organizations	not applicable
B) From the management school	
1) aggregate measures	involve all factors of production: not relevant
2) disaggregated measures:	
- specific ratios	applicable to our project
- compound ratios	deal with entire organization: too broad for our project.
- other measures:	
. control list	relevant for measuring effectiveness of activities concerned
- real dollar value	not applicable
- value of resources	not applicable to human context of study

C) **From the behaviorist school**

1) traditional ratios	deal with individual productivity: not relevant
2) systemic diagnosis	hard to apply: too broad for study framework
3) productivity profile	too broad for project
4) evaluation of organization	applies to macro-organizational level: not relevant